REMARKS

The Applicants request reconsideration of the rejection.

Claims 26- 27 remain pending.

On the Office Action Summary page, item 12, the Examiner has indicated that "some" of the priority documents have been received. The Applicants request the Examiner to acknowledge receipt of all of the certified copies of the priority documents in prior application, U.S. Serial No. 09/035,827. Priority is claimed to Japanese Application No. 09-052769, filed March 7, 1997, and Japanese Patent Application No. 09-060488, filed March 14, 1997, as indicated in the Declaration.

Claims 26-27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Byram, U.S. Patent No. 4,492,923 in view of Tomita et al., U.S. Patent No. 5,601,081 (Tomita). The rejection is identical to that set forth in the non-final Office Action mailed April 10, 2007, with the exception that the Examiner now cites Tomita as teaching isomagnetic fields for connecting points of magnetic fields at desired equal values, with reference to Figs. 21-22, 26, 28-29, 31, and 34. No reference to the Applicants arguments is set forth in the final rejection. Accordingly, the Applicants must assume that the only argument considered by the Examiner is that Tomita generally has no disclosure of the determination of an isomagnetic field map, or of displaying an isomagnetic field map.

Therefore, the Applicants again argue, and request the Examiner to consider, that the passages cited by the Examiner (col. 8, lines 45-56 (referring to Fig. 1), and col. 2, lines 1-46) do not teach or fairly suggest the claimed steps of (2) determining a value proportional to a root of $S(x,y,t) = \{\{\partial Bz(x,y,t)/\partial x\}^2 + \{\partial Bz(x,y,t)/\partial y\}^2\}$ from said magnetic field component (Bz(x,y,t)) in the z axis direction, and determining an isomagnetic field map obtained by connecting points at which said values

proportional to said root are equal to each other; and (3) displaying the isomagnetic field map, as required by both claims 26 and 27. Rather, col. 8, lines 45-56 of Tomita teach a data analyzing unit 8 that is used to deduce current sources in a region to be diagnosed of an examinee M from field data stored in a data collecting unit 5. The current sources are superimposed on sectional images previously obtained from a radiographic CT apparatus or MRI apparatus and displayed on a color monitor 10 or printed by a color printer 11. There is no disclosure of the determination of an isomagnetic field map, or of displaying an isomagnetic field map.

An isomagnetic field map is like a contour map for connecting points at which magnitudes of a magnetic field component measured at desired time points are equal to each other. Examples are shown in Figs. 14A-14C of the present application, including isomagnetic field maps at the moments of peaks of QRS waves obtained from a cardiac magnetic waveform. Further examples are shown in Figs. 24A-24C, 25A-25C, Figs. 26A-26C, and Figs. 29A-29B. Tomita does not show the determination or display of any such isomagnetic field map.

In fact, Tomita does not appear to consider isomagnetic field maps in the disclosed method and apparatus for deducing bioelectric current sources. Rather, in Tomita, a current dipole is estimated by estimating a current distribution with minimum norm and searching a lattice at which the current becomes maximum. Tomita measures minute magnetic fields formed by bioelectric current sources in a region under examination of an examinee, sets a plurality of lattice points in the region under examination, derives physical quantities of the current sources by solving a relational expression of unknown current sources at the lattice points and field data provided by magnetic sensors, with a condition added thereto to minimize the norm of a vector having the current source at each lattice point, moving the

lattice points toward a lattice point having a large current value among the computed current sources, checking whether a minimum distance among the lattice points having been moved is below a predetermined value, and repeating the current source computing step, lattice point moving step, and checking step for the lattice points having been removed, when the minimum distance exceeds the predetermined value, and regarding as a true current source the current source corresponding to a magnetic field occurring when the minimum distance is determined to be below the predetermined value at the checking step.

Thus, it is seen that Tomita not only fails to generally determine or display an isomagnetic field map, but does not determine an isomagnetic field map obtained by connecting points at which the value is proportional to the root of the equation set forth in claims 26-27 are equal to each other, or display such an isomagnetic field map, as required by both claims 26 and 27. Further, Tomita does not solve an inverse problem for estimating a position and magnitude of the magnetic field source within the living body, using the number of peaks and position data of the peaks in the isomagnetic field map as initial values for solving the inverse problem, as also required by claims 26 and 27.

Additionally, Tomita does not disclose or fairly suggest that the position data and number of peaks are designated on an isomagnetic field map as the initial values for solving the inverse problem, as required by claim 26. Tomita also does not teach or fairly suggest to calculate magnetic fields at a plurality of positions where the biomagnetic fields are detected, calculate an evaluation function expressed by the difference between the plurality of calculated biomagnetic fields and the detected biomagnetic fields at the plurality of positions where the biomagnetic fields are detected, or determine analytically the minimum value of the

evaluation function by changing positional coordinates of the current dipole to solve the inverse problem, wherein the position data and the number of peaks are designated on the isomagnetic field map as the initial values for solving the inverse problem, all as required by claim 27.

Because Tomita does not disclose these many features for which it is applied in the combination rejection with Byram, it necessarily follows that the combination of Byram and Tomita fails to render obvious the inventions claimed in claims 26 and 27.

As noted, the above argument is set forth, in its entirety, in the Reply filed July 10, 2007. To augment that argument, and to address the Examiner's citation to alleged isomagnetic maps in Tomita as noted above, the Applicants offer the following additional argument.

As mentioned above and in the Reply filed July 10, 2007, an isomagnetic field map connects points at which magnitudes of a magnetic field component measured at desired time points are equal to each other. A magnetic field component magnitudes result from biomagnetic field measurements generated by nerve action of the brain as well as by myocardial action of the heart of a living body, and are measured by using a plurality of fluxmeters each consisting of a highly sensitive superconducting quantum interference device (SQUID) in the preferred embodiments of the invention.

Various analysis methods are known which analyze a magnetic field source participating in generation of the biomagnetic field from the obtained isomagnetic field map, and in a typical one, analysis is carried out by replacing the magnetic field source with a current dipole. The method of Tomita is believed to be an example of such an analysis method which analyzes the magnetic field source by replacing the magnetic field source with a current dipole.

On the other hand, an isomagnetic field map of a normal component of the magnetic field generated by a current dipole is of a pattern having a source pole of magnetic field and a sink pole of magnetic field at positions which are separate from each other from the center where a magnetic field source (current dipole) is positioned. The magnitude, position and direction of the magnetic field source (current dipole) are analyzed in accordance with magnitudes of the magnetic field at the two poles and a distance therebetween.

Each of the conventional isomagnetic field maps of the respective components has inherent features. In the presence of a single current dipole, the position, magnitude and direction of a current source can be analyzed by using the isomagnetic field map of normal component B_z. On the other hand, the isomagnetic field map of two-dimensional vector magnitude B_{xy} obtained from measurement results of tangential components B_x and B_y features that even in the presence of a plurality of current dipoles, individual current dipoles can easily be discriminated from each other. However, for detection of a magnetic field, coils are required to be provided in x and y directions and the number of coils is doubled as compared to detection of only the normal component B_z. In vector measurement for measuring all components B_x, B_y, and B_z, the number of required coils is tripled as compared to detection of only the normal component B_z. Accordingly, the magnetic field sensor consisting of a detection coil and a SQUID is increased in number, and in addition, the signal processing circuit and the like are also increased in number, raising a problem that the biomagnetic field measuring system becomes expensive. Further, the prior art analysis providing only an arrow map for expressing a current vector J(x,y) on measuring points by using arrows merely indicates those measuring points, without discriminating detailed distribution states of current sources. Tomita does

not address any of these drawbacks of the prior art, inasmuch as Tomita does not disclose the employment of isomagnetic field maps as required by the claimed invention. Particularly, in failing to disclose or employ isomagnetic field maps, Tomita does not address any of the prior art problems with respect to this method.

Continuing, from the isomagnetic field map indicated in terms of a biomagnetic field component, the position, magnitude and direction, at a desired time point, of a current source in a living body can be analyzed, and detailed information about changes in position, magnitude and direction of the current source can be determined. In the prior art, however, many diagrams or maps indicating various kinds of information pieces would be needed for diagnosis, and abnormalities determinable from the changes in these various kinds of information pieces would have to be determined empirically. Therefore, the process of displaying, on a single map, systematic information as to what magnitude of current flows through which portion of a living body and as to which region an abnormal bio-current passes is not known.

In this case of a body surface potential map, an isointegral technique has been reported, in which the isointegral map is drawn by connecting the same integral values over a desired time interval. The advantage of this isointegral map is that information of the heart, for example, can be obtained from only a single electrocardiographic figure. However, in the isopotential map, when the current source in the heart is assumed to be a single current dipole, a figure results disadvantageously in which a positive peak and a negative peak do not exist immediately above the current dipole but exist at a position which is separated from a point immediately above the current dipole. Further, when the position of the current dipole remains unchanged but the direction of the current dipole changes,

the anode and cathode peak positions change, raising another problem that when the potential is integrated, correspondence between the current source and the peak of the integral value is impaired. In the example of the electrocardiogram, the mirror integration of a biomagnetic field component obtained through biomagnetic field measurement generates the problem that the peak position of the biomagnetic field component does not correspond to the position of the current source. Further, with only the isointegral map obtained from the electrocardiogram, because of individual differences such as the position and size of the internal organs, it is difficult to accurately determine an abnormality by simply gathering information from the isointegral map.

The Applicants respectfully submit that the present invention provides a biomagnetic field measuring method and apparatus which differs from and improves over the prior art, and namely that the present invention can grasp the entire state of the living body portion under measurement by using maps which are greatly reduced in number as compared to those maps required in the prior art. In particular, the present invention provides a biomagnetic field measuring method and apparatus which can permit analysis of a magnetic field source by measuring a vertical component B_z of a biomagnetic field without increasing the number of detection coils. As set forth in claim 26, a method of the present invention estimates a magnetic field source by measuring a magnetic field component (Bz(x,y,t)) in a z axis direction of a biomagnetic field generated from a living body by using a plurality of fluxmeters disposed externally of said living body, each fluxmeter including a superconducting quantum interference device (SQUID), wherein a plane parallel to the surface of said living body corresponds to the xy plane of a Cartesian coordinate system and a direction perpendicular to the surface of said living body corresponds to z axis of the

Cartesian coordinate system; determining a value proportional to a root of $S(x,y,t) = \{\{\partial Bz(x,y,t)/\partial x\}^2 + \{\partial Bz(x,y,t)/\partial y\}^2\}$ from said magnetic field component (Bz(x,y,t)) in the z axis direction, and determining an isomagnetic field map obtained by connecting points at which said values proportional to said root are equal to each other; displaying said isomagnetic field map; and solving an inverse problem for estimating a position and a magnitude of a magnetic field source within said living body, using the number of peaks and position data of said peaks in said isomagnetic field map as initial values for solving said inverse problem, and wherein a current dipole is assumed as said magnetic field source, wherein said position data and said number of peaks are designated on said isomagnetic field map as said initial values for solving said inverse problem.

As set forth in claim 27, another method according to the present invention estimates a magnetic field source by measuring a magnetic field component (Bz(x,y,t)) in a z axis direction of a biomagnetic field generated from a living body by using a plurality of fluxmeters disposed externally of said living body, each fluxmeter including a superconducting quantum interference device (SQUID), wherein a plane parallel to the surface of said living body corresponds to the xy plane of a Cartesian coordinate system and a direction perpendicular to the surface of said living body corresponds to the z axis of the Cartesian coordinate system; determining a value proportional to a root of $S(x,y,t) = \{\{\partial Bz(x,y,t)/\partial x\}^2 + \{\partial Bz(x,y,t)/\partial y\}^2\}$ from said magnetic field component (Bz(x,y,t)) in the z axis direction, and determining an isomagnetic field map obtained by connecting points at which said values proportional to said root are equal to each other; displaying said isomagnetic field map; and solving an inverse problem for estimating a position and a magnitude of a magnetic field source within said living body, using the number of peaks and position

data of said peaks in said isomagnetic field map as initial values for solving said inverse problem, wherein the solving step includes calculation of magnetic fields at a plurality of positions (x,y) where said biomagnetic fields are detected, on the assumption that a current dipole being assumed as said magnetic field source generates a magnetic field indicated by the Bio-Savart formula at said plurality of positions (x,y), calculation of an evaluation function expressed by the difference between said plurality of calculated magnetic fields and said detected biomagnetic fields at said plurality of positions (x,y), and determination analytically of the minimum value of the evaluation function by changing positional coordinates of said current dipole to solve said inverse problem, and said position data and said number of peaks are designated on said isomagnetic field map as said initial values for solving said inverse problem.

Turning now to the Examiner's added comment regarding Tomita, the cited figures pertain to the Fifth Embodiment beginning in col. 17, line 13 of the patent. Specifically, according to the patent, field data are collected from the Examinee M by a multichannel SQUID sensor 1, and in a sequence of current deduction, a three-dimensional arrangement of lattice points is used. A current source is present in the position marked with a circle (Fig. 21) and arrows and black spots indicate lattice points. Lattice points having large current values are indicated by large black spots, while lattice points having larger current values are indicated by arrows. Lattice points having small current values do not appear in the figures.

Fig. 21 shows current sources [P] deduced immediately after the lattice points were set evenly. The square error was $f=1.454925e^{-03}$ at this time. Fig. 22 shows current sources [P] after the lattice points were moved plural times. As noted in col. 19, lines 9-11, the lattice points have been collected around the true current

source in Fig. 22. The lattice points having large current values as indicated by the arrows appear adjacent the true current source. The square error was small $f=4.119901e^{-06}$ at this time. Fig. 23 shows positions of the current sources when the square error is minimized. The plurality of lattice points having large current values as indicated by the arrows in Fig. 22 now overlap the true current source, showing that the true current source is deduced correctly, according to Tomita.

Thus, Tomita discloses that Figs. 21-23 illustrate the finding of stable solutions (current sources [P]) that are derived from magnetic fields measured by magnetic sensors arranged according to the prior art. The current sources are derived from the measured magnetic fields so as to minimize the square error between the magnetic fields [B] due to unknown current sources [P] at the lattice points and the magnetic fields [Bd] measured by the magnetic sensors. There is no disclosure of determining magnitudes of a magnetic field component measured at desired time points that are equal to each other. Further, there is no disclosure of connecting such points at which the magnitudes of the magnetic field component measured at desired time points are equal to each other. Accordingly, Tomita successfully derives the views of Figs. 21-23, in contrast to the isomagnetic field maps required by claims 26 and 27 (which would look more like Figs. 14A – 14C of the present application). Tomita does not show the determination or display of any such isomagnetic field map in Figs. 21-23, or in the other figures mentioned in the Office Action.

Accordingly, Tomita does not determine an isomagnetic field map obtained by connecting points at which values proportional to a root of $S(x,y,t) = \{\{\partial Bz(x,y,t)/\partial x\}^2 + \{\partial Bz(x,y,t)/\partial y\}^2\}$ from a magnetic field component ($Bz(x,y,t)$) in the z-axis direction are equal to each other; Tomita does not display such an isomagnetic field map so

determined; and Tomita does not solve an inverse problem for estimating a position and a magnitude of a magnetic field source within a living body, using the number of peaks and position data of the peaks in the isomagnetic field map as initial values for solving the inverse problem. Further, assuming Tomita's current dipole as the magnetic field source, Tomita does not designate the position data and the number of peaks on an isomagnetic field map as initial values for solving the inverse problem.

Claim 27 is likewise patentable because Tomita does not disclose a step of determining an isomagnetic field map obtained by connecting points at which values proportional to a root of $S(x,y,t) = \{\{\partial Bz(x,y,t)/\partial x\}^2 + \{\partial Bz(x,y,t)/\partial y\}^2\}$ from the magnetic field component (Bz(x,y,t)) in the z-axis direction are equal to each other; a step of displaying the isomagnetic field map; and the step of solving an inverse problem for estimating a position and a magnitude of a magnetic field source within a living body, using the number of peaks and position data of the peaks in the isomagnetic field map as initial values for solving the inverse problem. Further, Tomita does not disclose or fairly suggest that solving such an inverse problem includes calculation of magnetic fields at a plurality of positions where biomagnetic fields are detected, on the assumption that the current dipole being assumed as the magnetic field source generates a magnetic field indicated by the Biot-Savart formula at the plurality of positions, calculation of an evaluation function expressed by the difference between the plurality of calculated magnetic fields and the detected biomagnetic fields at the plurality of positions, and determination analytically of the minimum value of the evaluation function by changing positional coordinates of the current dipole to solve the inverse problem, wherein the position data and the

number of peaks are designated on the isomagnetic field map as the initial values for solving the inverse problem.

The Applicants' representative requests an interview with the Examiner at a mutually convenient time to be determined. To this end, the Applicants' representative will telephone the Examiner to schedule the interview.

In view of the foregoing amendments, the Applicants request reconsideration of the rejection and allowance of the claims.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, or credit any overpayment of fees, to the deposit account of Mattingly, Stanger & Malur, P.C., Deposit Account No. 50-1417 (referencing attorney docket no. ASA-701-04).

Respectfully submitted,

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